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HST Instrument Modes vs. Observations: Lessons for NGST

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ABSTRACT

A review of the history of HST usage shows that a relatively small fraction of operational modes supported most of the observations. This suggests that future telescopes, such as NGST, could be designed with less complexity without compromising their scientific goals.

Introduction

The Next Generation Space Telescope (NGST) must be efficient both in design and operation. The available budget for scientific instruments is comparable to the HST STIS and NICMOS instruments (about $225M) and must provide a NIR camera with a larger field of view and format than the ACS, a multiobject spectrometer capable of producing hundreds of galaxy or stellar spectra over a wide field of view and a Mid-IR camera spectrograph of moderate complexity. Likewise, the operations budget for NGST is significantly lower than the HST operations budget, while the overall data flow will be significantly higher. For these reasons, we must search for methods of reducing cost in both development and operations while maintaining scientific productivity. One area which drives both development cost and operational complexity is the number of operational modes for the science instruments. To gain some insight into the number of modes used on HST instruments, we have looked at the distribution of scientific observations as a function of mode. Not surprisingly, we find that a small percentage of modes account for a large percentage of observations. In the body of this report, we present statistical data for the eight HST instruments prior to the third servicing mission. However, we can summarize the results as follows.

In order of mode complexity, the instruments can be ranked from simplest to most complicated as: GHRS (14), FOC (73), FOS (168), HSP (276), WFPC (309), STIS (357), WFPC2 (583), and NICMOS (634) (the definition of mode is complex and is discussed, in detail, in the NICMOS and FOC sections). Several obvious lessons can be learned from these data:

- Difficulties with detectors and subsequent operational workarounds can lead to doubling or tripling the number of modes and the complexity of subsequent calibrations (WFPC).
- Relative complexity is hard to estimate purely from the number of adjustable parameters. Cameras with discrete integration times can appear as complex as sophisticated multifunctioning spectographs.

In the order of mode efficiency (number of modes needed to achieve 90% of the observations), the instruments can be ranked from most efficient (fewest modes) to least efficient as: GHRS (10), FOS (61), STIS (101), WFPC (103), WFPC2 (115), HSP (132), NICMOS (188), FOC (222). The small number of modes required for the GHRS is impressive-an order of magnitude lower than for the other instruments.

In order of design efficiency (relative number of modes needed to achieve 90% of the observations -- the relative overkill of the design), the rankings are quite different. Most efficient in this case are the instruments with the highest percentage of modes required to achieve 90% of the scientific observations. They are as follow: GHRS (71%), HSP (48%), FOS (36%), WFPC (33%), FOC (33%), NICMOS (30%), STIS (28%), and WFPC2 (20%). It is important not to take these results too literally. Many of the FOC modes were negatively affected by spherical aberration. Some (FOC coronagraphy) were permanently lost. However, these statistics raise several interesting questions:

- Could several of these instruments have been designed to use 70% fewer modes and still address most of the science?
- How do these results compare to predictions of scientific usage made during the design phase?

Based on these data, we suggest limiting the number of operational modes for the NGST instruments to 10-20 modes for the imager and a similar number for the spectrograph not counting individual settings for a programmable slit, readout patterns, and gain changes. These latter parameters do not require independent calibrations for every filter or grating.

In the remainder of this report, we provide tables and graphs showing the cumulative number of scientific observations made with HST up to November 1999 versus instrument mode. We define a mode as a selected combination of instrument settings that significantly affect the outcome of an observation and generally requiring a qualitatively different calibration. For instance, the GHRS mode is defined by the choice of detector, grating, aperture, and spectral order. Since we only use modes for which scientific observations were obtained, we have removed any degeneracy within these parameters (i.e. if a given HSP detector is always used with a given aperture, this mode is not counted twice). Also, it was useful to look at each element separately, to see the individual element use versus the total number of observations. Yet another way was to look at exposure times for each mode (all exposure times are given in seconds). The cumulative exposure time usually, but not always, followed the cumulative count of observations in a particular mode.

Raw numbers, however, can be misleading. We've tried to normalize our study across instruments, as much as possible. In most cases, there is a combination (mode) versus number of observations, an individual element (elements of the mode) versus number of observations, and an exposure time for each mode versus number of observations.

Table 1. Below is an outline of what each instrument team has provided and those whose gracious help made this paper possible:

Instrument	**Contact Scientist**	**Contribution**
WFPC2	Sylvia Baggett	1) Mode Combination 2) Individual Element 3) Exposure Time
NICMOS	Alex Storrs	1) Mode Combination 2) Separate Modes 3) Individual Element 4) Exposure Time
FOC	Robert Jedrzejewski	1) Separate Mode a. F/48 b. F/96
FOS	Tony Keyes	1) Mode Combination 2) Individual Element 3) Exposure Time a. full configuration vs. exp time b. grating vs exp. time c. wavelength vs. exp. time
GHRS	Ron Gilliland	1) Mode Combination 2) Individual Element Modes 3) Exposure Time
HSP	Rick White	1) Mode Combination 2) Individual Element Modes 3) Exposure Time a. full configuration vs. exp time b. apertures (DIG) vs exp. time c. apertures (ANA) vs. exp. time
WFPC	Sylvia Baggett	1) Mode Combination 2) Individual Element
STIS	Gerard Kriss	1) Mode Combination 2) Individual Element Modes

We tried to point out cases that were needed for a particular function even though their percentages (frequency of use) were low. This study has not looked into the merit of individual science observations, nor the actual cost of any of these elements. Such an evaluation would be too speculative and subjective.

INSTRUMENTS

WFPC2

The database queries used to generate this information looked into the **dadsops** database, at relations wfpc2_ref_data and wfpc2_primary_data. Parameters limiting the queries were

```
where w.w2r_imagetyp=”EXT”
```

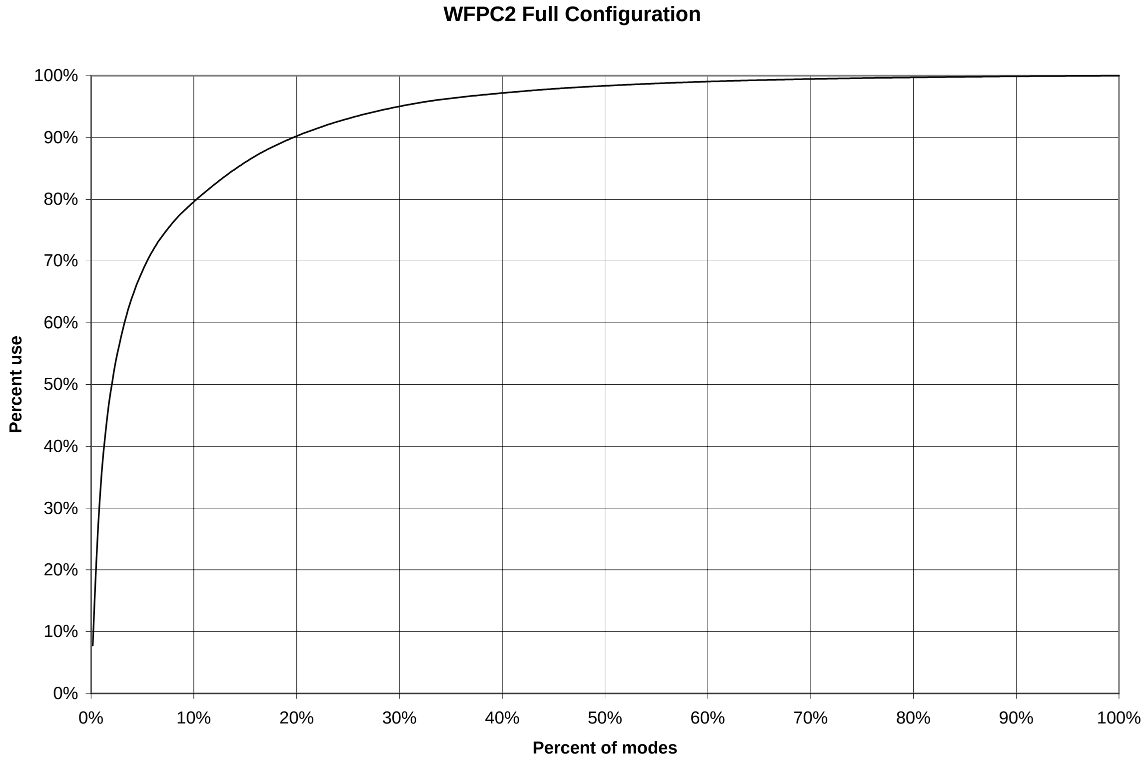
1. Combination Section

A mode (or configuration) existing of the combinations of filter1, filter2, mode, atod-gain, serials, and shutter is one possible definition. This gives us 60341 observations taken with 583 modes, 90% of the observations (54328/60341) make use of only 20% of the modes (115/583). See figure 1. This study for WFPC2 looked at data taken between December 1993 and December 1999.

An example of a full configuration would be

```
filter1 = F300W
filter2 = NULL
mode    = AREA
atodgain= 7.000000
serials = ON
shutter = A
```

Figure 1:



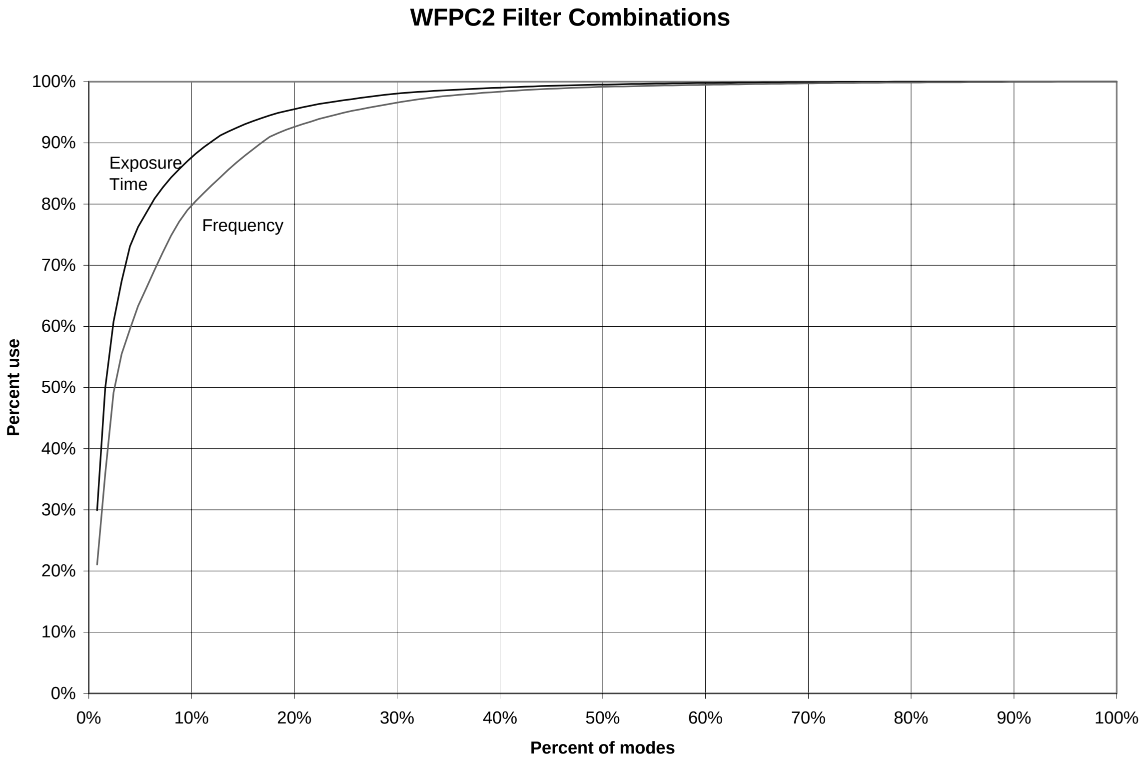
2. Individual Element Section

- The filters are used in combinations, that is, (filter1/filter2). 90% (54197/60201) of the observations were made with only 17% (21/125) of the total filter combinations. See figure 2.
- The element (MODE = AREA) was used only 0.2% of the time. Had it been eliminated, the number of flats calibrations taken with the WFPC2 would have been reduced by 50%, although it would remove the capability to do on-chip summation (which reduces read noise). The number of bias and darks would also have been reduced.
- The element (SERIALS=ON) was used only 8.4% of the time but its use doubled the number of dark calibrations taken on orbit. Clearly these rarely used modes come at a significant operational cost both in terms of data transmission and storage but also calibration analyses. Saturated targets and bleeding control both need (SERIALS=ON).

3. Exposure Time Section

Yet another way of looking at the filter use is to examine the exposure time for each filter combination, relative to the frequency of uses, to see if any particular filter is weighted in these counting schemes. This is interesting since it shows that 12% (15/125) of the filter combinations used 90% (25135520/27840518 sec) of the observing time. This is another argument suggests that one could downsize the filter selection. Figure 2 shows both filter combination use vs. total number of observations and filter combination vs. total observing time.

Figure 2:



NICMOS

The database queries used to generate this information looked into the **dadsops** database, at relations nicmos_ref_data, nicmos_science.
Parameters limiting the queries were

```
where s.nss_imagetyp=”EXT” and
n.nsr_data_set_name=s.nss_data_set_name and
n.nsr_data_set_name like “%S” or
n.nsr_data_set_name like “%Q” or
n.nsr_data_set_name like “%N” or
n.nsr_data_set_name like “%R” or
n.nsr_data_set_name like “%M” or
n.nsr_data_set_name like “%0”) and s.nss_obsmode!= “ACCUM”
and s.nss_obsmode != “BRIGHTOBJ”
```

or, only external observations, datasets ending in a S,Q,N,M,or R, and not ACCUM or BRIGHTOBJ obsmode. The query was limited to data taken between March 1997 and January 1999. If we were to redesign NICMOS today, the ACCUM obsmode would not be part of the plan.

An example of a mode

```
camera   = 3
filter   = G096
samp_seq = STEP1
obsmode  = MULTIACCUM
```

1. Combination Section

One possible definition of a mode (or configuration) is defined by the following parameters: camera, filter, samp_seq, and obsmode. We find 634 modes and 39398 observations; 90% (35451/39398) of the observations use only 30% (188/634) of the modes. Defining the modes in this way, we could conclude that redesigning of the instrument would eliminate approximately 70% of the modes. This count is comparable to all other instruments, modes vs. observations; but it overestimates the number of independent modes on NIMCOS.

Not all 634 modes needed to be calibrated. This number 634 is a product of the camera * filter * samp_seq * obsmode, possible values. These modes require calibration, thus affecting the operation of the instrument. Many of these could be eliminated without significantly impacting the data volume. It is difficult to define a NICMOS mode in this way, it is necessarily incomplete. From a calibration viewpoint, for each camera we take darks, flats, and photometric standards. The photometric standards are only done for a few samp_seqs, and therefore, don't make a big impact.

Thus the total number of modes for NICMOS should be

```
modes           = #cameras * (#filters + #samp_seqs)
where #filters  => flats
#samp_seqs      => darks
```

Thus Section 3 gives the best picture of NICMOS usage, although with time, the filter use should even out.

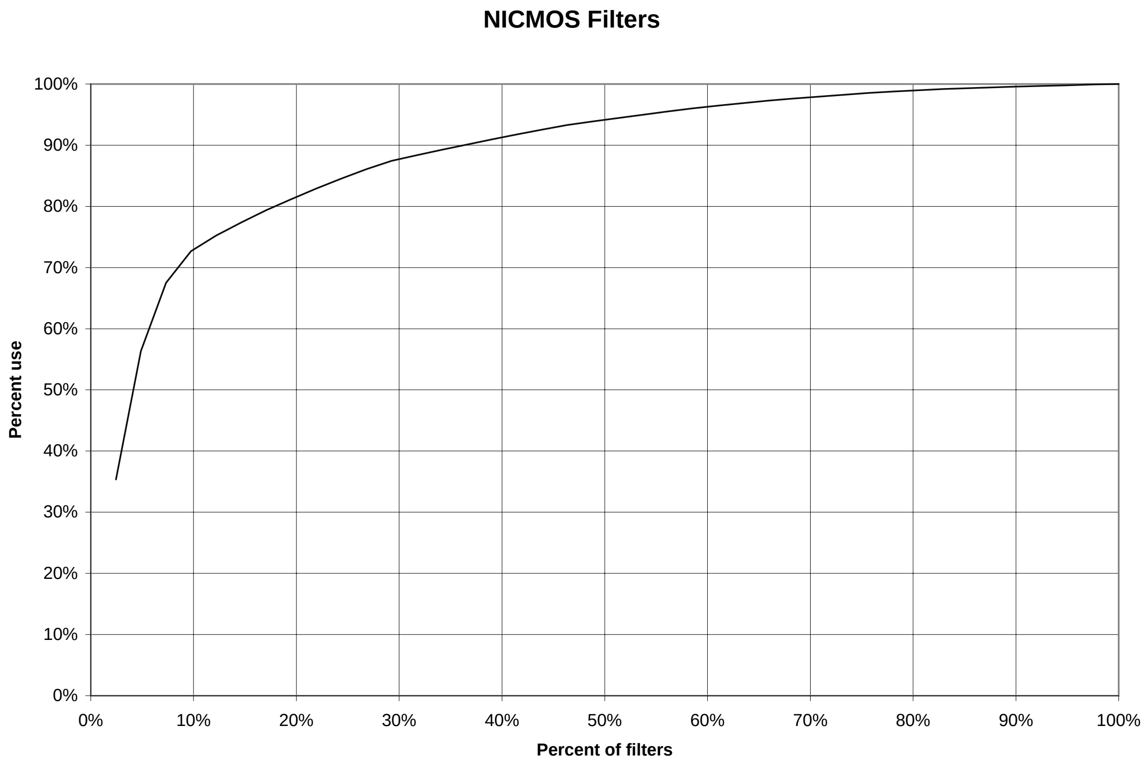
2. Separate Modes Section

Another way of defining a mode is the combination of the camera and samp_seq values, which gives us 46 modes. With this definition, 90% (35452/39398) of the observations used 58% (27/46) of the modes. The combination of a camera and filter gives 57 modes, and 90% (35343/39398) of the observations used 46% (26/57) of the modes.

3. Individual Element Section (Individual elements vs observations)

- camera - the use of the cameras is fairly evenly distributed. (1-24%,2-43%,3-34%). See figure 4.
- filter - 90% (35231/39100) of the observations use 37% (15/41) of the filters. See figure 3 and Figure 4.

Figure 3:



- samp_seq - the samp_seq values are spread fairly evenly as well. 90% (35281/39398) of the observations used 73% of the samp_seq values. This was fairly efficient.
- obsmode - 99% of the obsmodes were MULTIACCUM.

4. Exposure Time Section (Exposure time vs. “full” mode vs. number of observations).

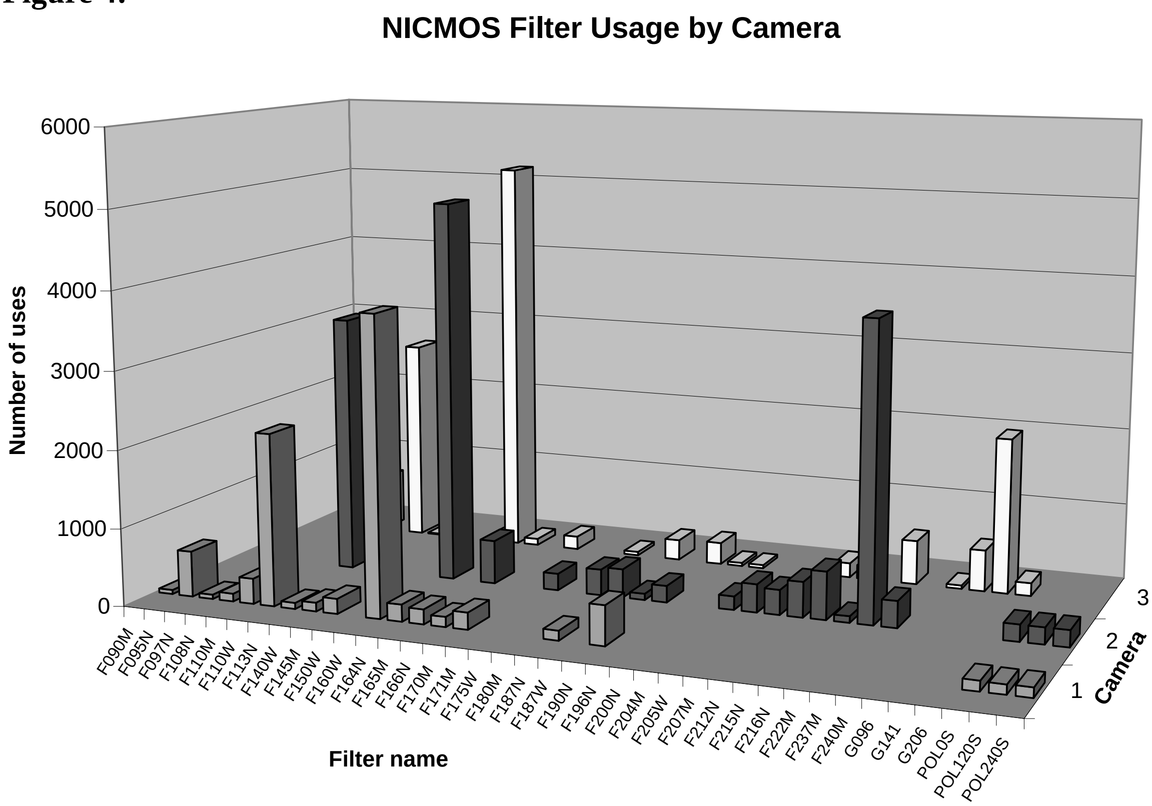
This comparison isn’t very meaningful, unlike some of the other instruments. A defined samp_seq has a definite series of exposure times which are calibrated all at once. Therefore, this section is not included in the NICMOS portion of this study.

Conclusions

In Section 1, we look at the full combination of modes vs. frequency of use. For example, it looks like camera 3 with the G096 and step1 sampseq is not well used, but what would you eliminate? Camera 3? G096? Step1? Thus you have to look at NICMOS modes individually, as was done in section 3. The fact that they were used together is irrelevant. You have to look at total usage among the cameras, AND total usage among the spectal elements, AND total usage among the samp-seqs (where AND is used in the Boolean sense). Section 3 is the proper way to look at NICMOS usage. It would be interesting to see how these statistics would develop over time, since deeper more focused science may lead to using higher spectral resolution. If NICMOS had worked for 4-5 years as intended, we think that the filter use would be more even. To date, the filter use is skewed by the broadband surveys, and perhaps by the parallel programs.

Figure 4 lends support in a broader view, that a small number of filters support most of the observations. It also shows that the camera use is fairly even.

Figure 4:



FOC

The database queries used to generate this information looked into the **dadsops** database, at relations foc_ref_data and proposal.

Parameters limiting the queries were

```
where n.fcr_shtmode=”NOTUSED” and
p.pro_proposal_type != “SV” and
p.pro_proposal_type != “OV” and
p.pro_proposal_type != “CAL/FOC” and
p.pro_proposal_type != “OV/FOC” and
p.pro_proposal_type != “ENG/FOC” and
p.pro_proposal_type != “SM2/FOC” and
p.pro_proposal_type != “SME/FOC” and
p.pro_proposal_type != “SMC/FOC” and
p.pro_proposal_type != “SV/FOC” and
p.pro_proposal_type != “ENG” and
p.pro_proposal_type != “NULL”
```

This query looked at data taken between July 1990 and June 1999.

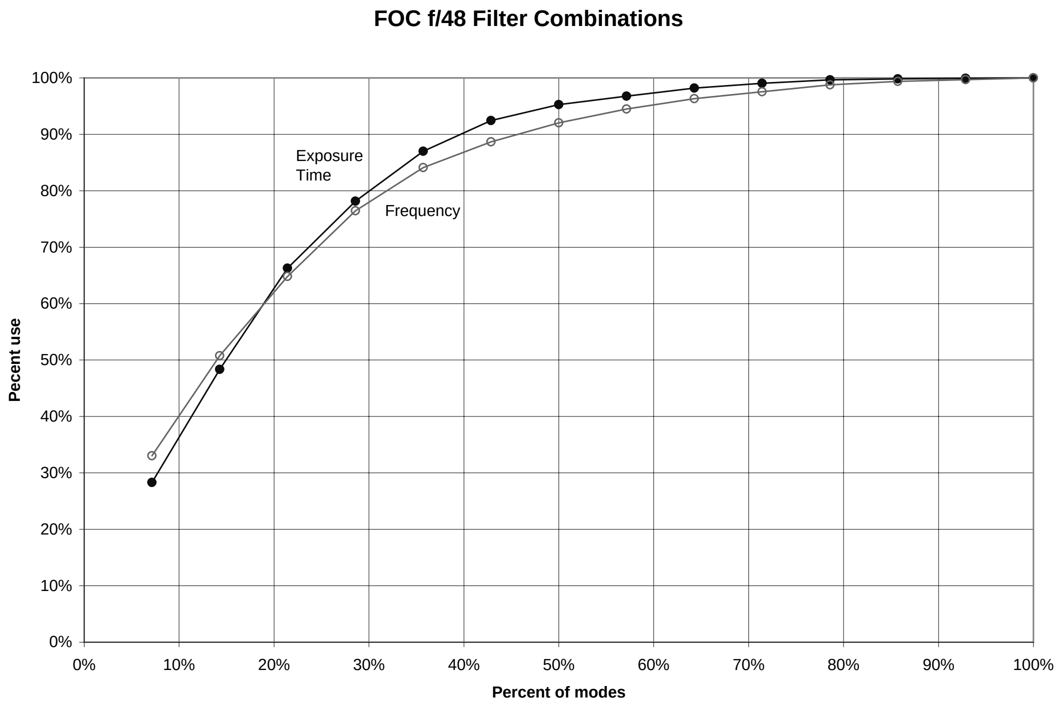
The definition of a mode for the FOC first involved a choice of optical paths, F/48 or F/96. A meaningful study of this instrument looks at the filter combinations with either of these two paths. The F/96 mode was used 91% (3320/3647) of the time, and the F/48, 9% (327/3647) of the time

1. Separate Modes

a. F/48

(2 filter wheels, 8 slots/wheel, 14 combinations and 327 observations) 92% (400460/460276 sec) of the exposure time used 43% (6/14)of the filter combinations. 92% (290/327) of the observations used 50% (7/14)of the filter combinations. See figure 5.

Figure 5:



Filtname 1	Filtname 2	Number of observations
F195W	F342W	1
F220W	F275W	1
F140W	CLEAR2	2
F195W	CLEAR2	4
CLEAR1	F180LP	4
PRISM3	F130LP	6
F175W	CLEAR2	8
CLEAR1	F342W	11
F150W	F130LP	15
CLEAR1	F430W	25
F150W	CLEAR2	38
CLEAR1	F275W	46
F305LP	CLEAR2	58
F220W	CLEAR2	108

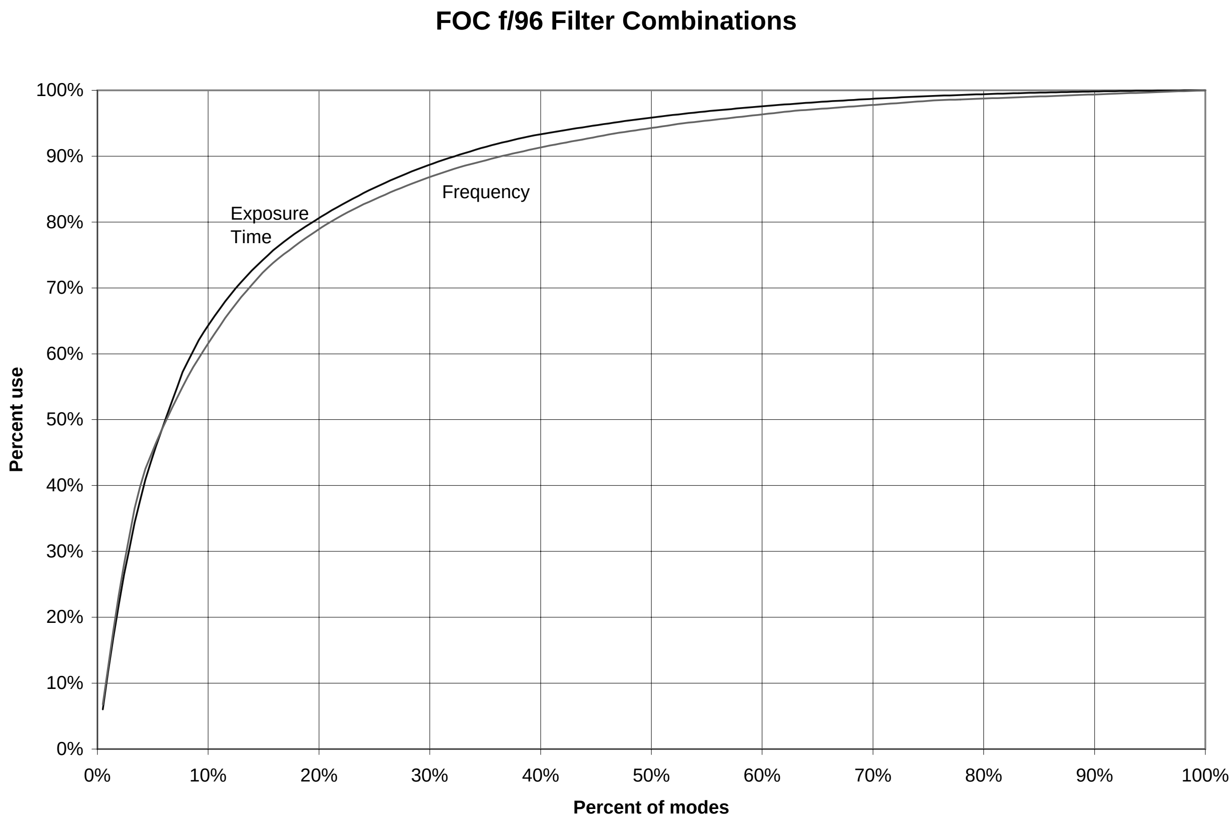
Taking the seven most used filters, regardless of wheel, to see how we could put the most commonly used filters in just one wheel:

Filtname	Number of observations
F220W	108
F305LP	58
F275W	46
F150W	38
F430W	25
F342W	11
F175W	8
F180LP	4
Total	298/ 327=91.1%

i.e. we could have done >90% of the F/48 program with only one filter wheel.

b. F/96
(4 filter wheels, 12 slots/wheel, 50 combinations, 3320 observations. 90% (3474382/ 3861887 sec) of the exposure time used 32% (67/208)of the filter combinations. 90% (2988/3320)of the observations used 37% (76/208) of the filter combinations. See figure 6.

Figure 6:



Populating two filter wheels with the following filters:

FW1	FW2
PRISM1	F342W
POL0	F175W
POL60	F486N
POL120	F430W
PRISM2	F170M
CLEAR	CLEAR
F152M	F140W
F2ND	F275W
F130M	F120M
F1ND	F220W
F372M	F502M
F501N	F480LP

gives these allowed combinations:

filter	filter	freq	filter	filter	freq
CLEAR1	F220W	225	POL0	F430W	7
CLEAR1	F342W	188	POL120	F170M	4
CLEAR1	F486N	184	POL0	F170M	4
PRISM1	CLEAR2	177	PRISM2	CLEAR2	43
CLEAR1	F430W	159	PRISM2	F175W	18
CLEAR1	F140W	142	PRISM2	F275W	5
CLEAR1	F175W	138	CLEAR1	F275W	40
CLEAR1	F501N	107	PRISM1	F120M	4
CLEAR1	F480LP	92	PRISM1	F140W	4
F120M	CLEAR2	67	F130M	CLEAR2	42
POL60	F342W	63	F2ND	F140W	1
POL120	F342W	54	F2ND	F175W	1
POL0	F342W	53	F2ND	F275W	1
F170M	CLEAR4	62	F140W	F130M	11
F175W	F152M	58	F2ND	F220W	9
F152M	CLEAR4	23	POL120	F275W	5
CLEAR1	F372M	57	POL0	F502M	3
CLEAR1	F502M	52	POL60	F502M	3
F2ND	F486N	48	POL120	F502M	3
F2ND	F430W	30	F2ND	F480LP	4
F2ND	F342W	20	F430W	F1ND	24
F2ND	F170M	18	F342W	F1ND	12
F152M	F140W	5	F480LP	F1ND	9
POL120	F430W	10	CLEAR1	CLEAR2	7
POL60	F430W	7	F486N	F1ND	7
Total	2310 / 3320=69.6%				

This method produces a measure of the value of two of the filter wheels in the F/96 relay as compared to the four that are actually present. It shows that 70% (2310 / 3320) of the observations could have been made with half of the filters.

It is difficult to allow for the importance of the individual observations: for example a single snapshot exposure is given the same weight as a (hypothetical!) exposure that imaged an extrasolar planet. Also, there is no accounting for the cost of adding the filters: some filters are MUCH more expensive to manufacture than others. However, it does give a more useful description than just counting the filter combinations that have been used and working out what fraction of these combinations could have given a large fraction of the observations: such a methodology does not take into account fixing which filters go on which wheel and the constraints of using only two wheels.

FOS

The database queries used to generate this information looked into the **dadsops** database, at relations fos_ref_data, science. Parameters limiting the queries were

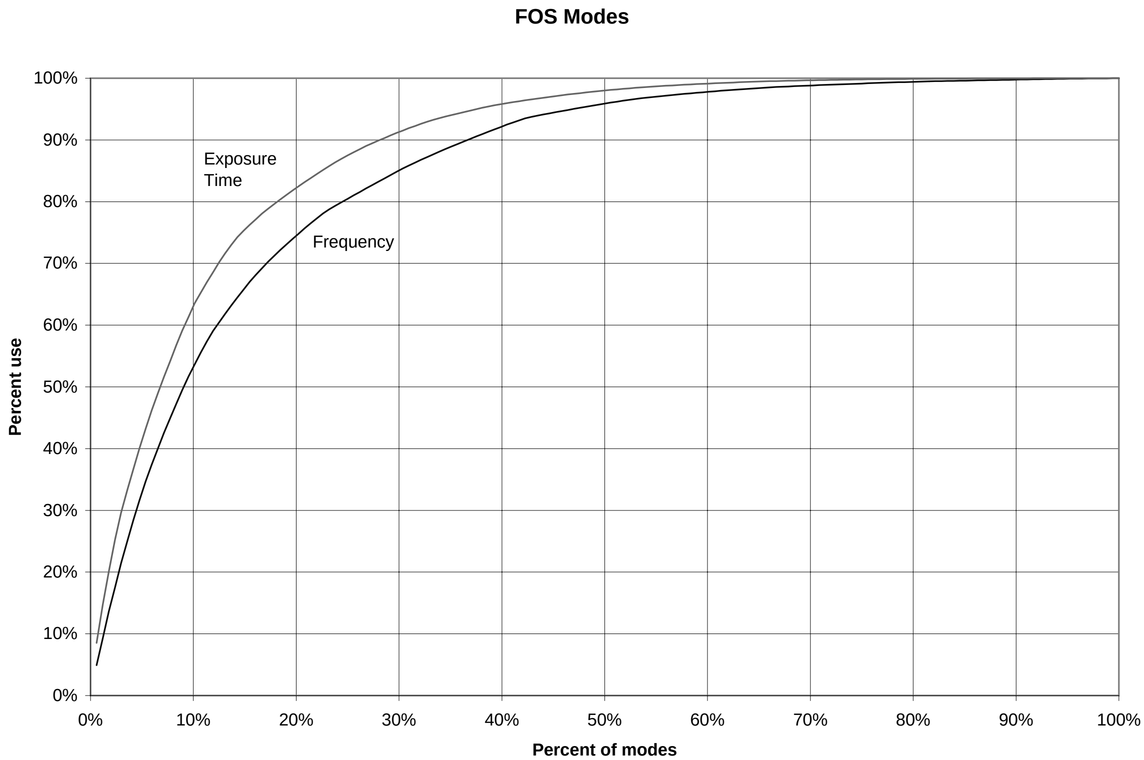
```
where s.sci_targname != “TALED” and
s.sci_targname != “WAVE” and
s.sci_targname != “DARK” and
n.fsr_overscan = 5 and
n.fsr_grndmode != “TARGET ACQUISITION” and
not (n.fsr_fgwa_id = “CAM” and n.fsr_grndmode =
“SPECTROSCOPY”)
```

and the query looked at data taken between September 1990 and February 1997.

1. Combination Section

A mode (or configuration) existing of the combinations of aper_id, fgwa_id, detector, overscan and polar_id is one possible definition. This gives us 10576 observations taken with 168 modes, or 90% (9494/10576); 36% of modes (61/168). See figure 7.

Figure 7:



An example of a configuration

```
aper_id   = A-1
fgwa_id   = H40
detector  = BLUE
overscan  = 5
polar_id  = A
```

2. Individual Elements Section

- Out of eleven different apertures, six were used 55% (9708/10576) in 92% of the observations.
- The polar_id=C (no polarizer) was used in 96% (10189/10576) of the observations.

Looking at these numbers, one might draw a conclusion that five of the apertures were not needed, and two of the polar_id choices were not needed (polarization measurements were uncommon). However, polarization measurements provide special information not contained in unpolarized observations.

3. Exposure Time Section

- Full configuration: 90% (9290326/10336653 sec) of the total exposure time used 28% (47/168) of the modes. See figure 7.
- Gratings: The HGratings (L65,L15, & PRI) were used 23% of the time for 26% of the observations, versus the HGrating = CAM, which was utilized only .3% of the time, and for 7% of the observations.

HGRATING: L & PRI vs. CAM

fsr_fgwa_id	sum of exp-time (sec)	freq of observations
L65	310394	451
PRI	421070	697
L15	1599898	1635
Total=	2331362	2783

[23% of the time(2331362/10336653 sec); 26% of observations - 2783/10576]

fsr_fgwa_id	sum of exp-time (sec)	freq of observations
CAM	38153	766

[.3% of time(38153/10336653 sec); 7% of the observations (766/10576)]

- Wavelength: Comparing the wavelengths of the gratings, Ultraviolet vs. Optical, we see that the ultraviolet gratings (L15,H13,H19,& H27) were used 77% of the total time and in 64% of the observations. The optical gratings were used far less, at 19% of the time, and 22% of the total observations.

ULTRAVIOLET VS OPTICAL
(L15,H13,H19,& H27) vs (H40,H57,H78,& L65)

fsr_fgwa_id	sum of exptime (sec)	freq of observations
L15	1599898	1635
H27	1914495	1902
H13	2061986	1293
H19	2345218	1937
	Total = 7921598.	6767

[77% of time (7921599/10336653 sec); 64% of observations (6767/10576)]

fsr_fgwa_id	sum of exptime (sec)	freq of observations
H78	154953	184
L65	310394	451
H40	614268	894
H57	876215	817
	Total = 1955831	2346

[19% of time(1955831/10336653 sec); 22% of observations (2346/10576)]

For an overall view, below is the listing of all grating, their accumulated time, and frequency of use.

ALL GRATINGS:

fsr_fgwa_id	sum of exptime (sec)	freq of observations
CAM	38153	766
H78	154953	184
L65	310394	451
PRI	421070	697
H40	614268	894
H57	876215	817
L15	1599898	1635
H27	1914495	1902
H13	2061986	1293
H19	2345218	1937
	Total= 10336653	10576

GHRS

The database queries used to generate this information looked into the **dadsops** database, at relations hrs_ref_data and hrs_data. Parameters limiting the queries were

```
(n.hsr_grating != “NDF”)and
(n.hsr_grating != “SAF”)and
(n.hsr_grating != NULL)and
(n.hsr_aperture != “NONE”)and
(n.hsr_aperture != “ERROR”)and
(n.hsr_aperture != “SC1”)and
(n.hsr_aperture != “SC2”)and
(n.hsr_grating != “MIRROR-A1”)and
(n.hsr_grating != “MIRROR-A2”)and
(n.hsr_grating != “MIRROR-N1”)and
(n.hsr_grating != “MIRROR-N2”)
```

and the query looked at data taken between September 1990 and February 1997.

1. Combination Section

The combination of grating and aperture gives us a total of 14 modes and 8722 observations. 90% (7820/8722) of the observations were made with 64% (9/14) of the modes. Neither mirrors nor the detectors are included in this count. The mirror observations were not direct science, but for science support and the detectors are unique to each grating. From this mode or configuration examination, the GHRS was very simple and efficient. See figure 8.

An example of a configuration would be

```
grating  = ECH-A
aperture = SSA
```

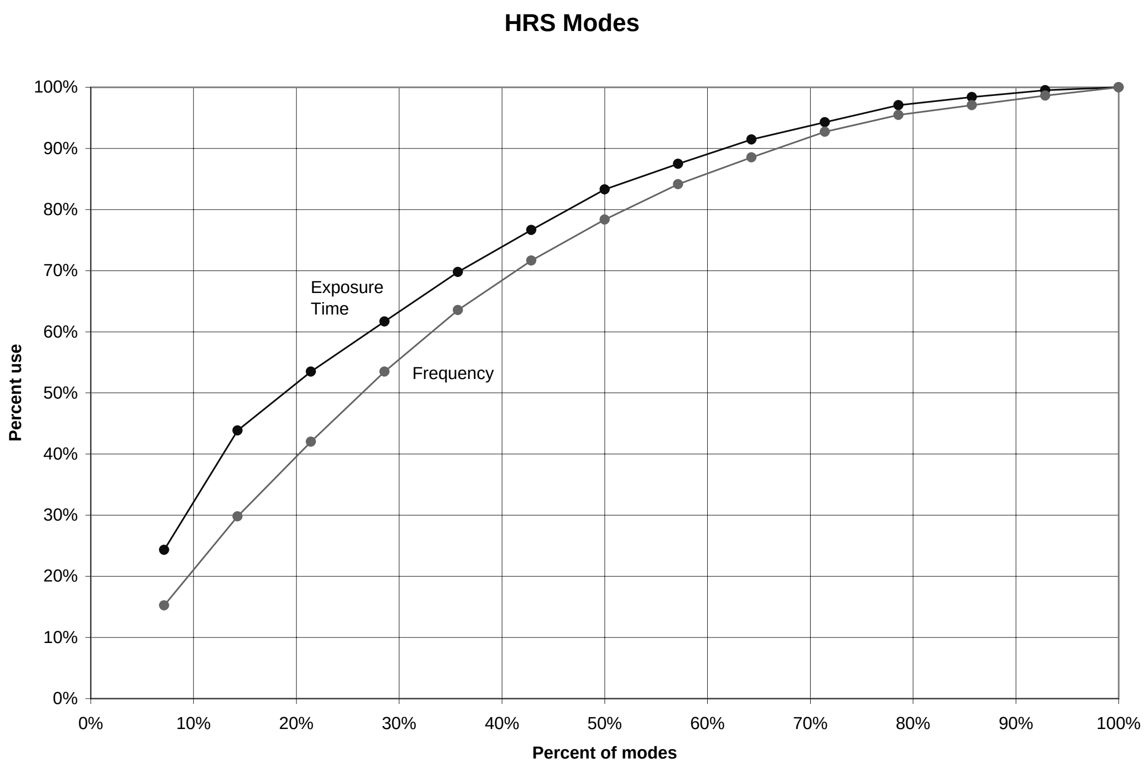
2. Individual Elements Section

- Grating... 93% (9902/10625) of total observations with 58% (7/12) of the gratings used.
- Aperture is roughly 60/40 - LSA/SSA.
- Detector is roughly 30/70% detector=1 to 2.
- Sporder values 90% (7819/8689) observations; 48% (16/33) of the allowed sporder values.

3. Exposure Time Section

Gratings vs. time vs number of observations; 92% (7901026/8638346 sec) of the exposure time 64% (9/14) of the modes. See Figure 9.

Figure 8:



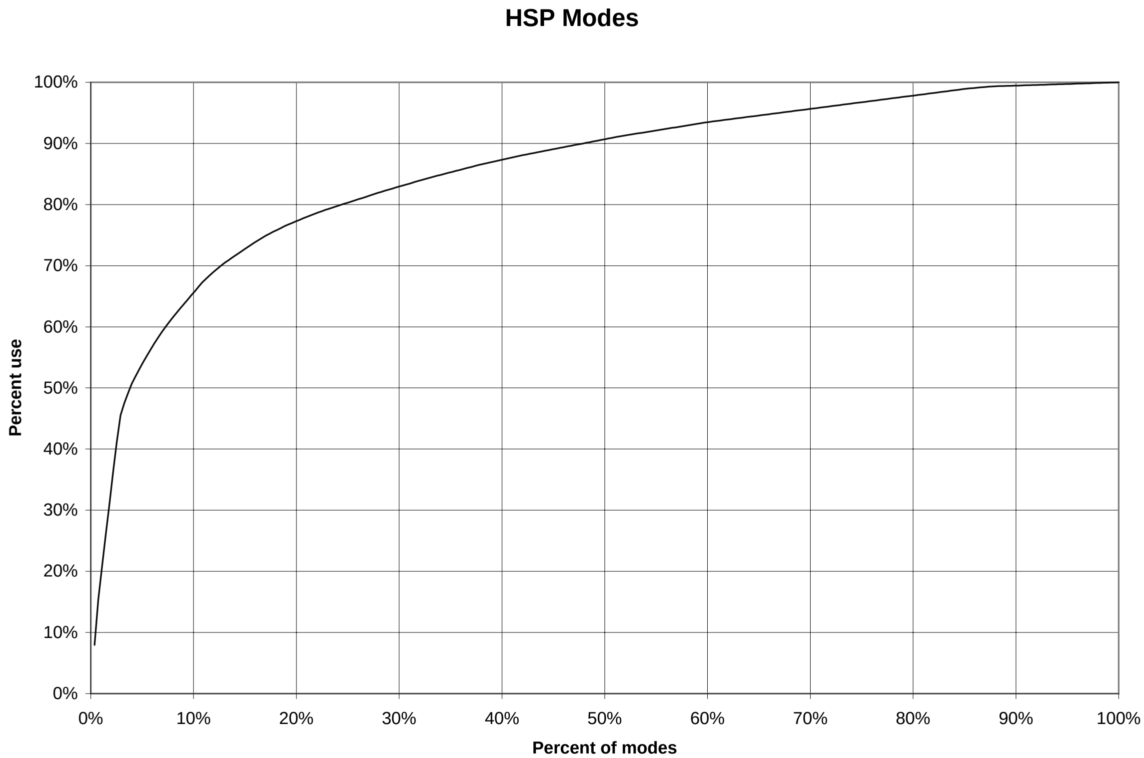
HSP

The database queries used to generate this information looked into the **dadsops** database, at the relation hsp_ref_data. The query looked at data taken between April 1990 and December 1993

1. Combination Section

A mode (or configuration) existing of the combinations of data_type, thresh, vgaind, detectob, and apertobj is one possible definition. This gives us 5089 observations taken with 276 modes, or, 90% (4567/5089) of the observations make use of 48% (132/276) of the modes. See figures 9 and figure 10.

Figure 9:



An example of a configuration would be

```
data_type = DIGITAL
thresh    = 1
vgaind    = 7
detectob  = 2
voltage   = 203
apertobj  = VCLRU1_A
```

Individual Elements Section

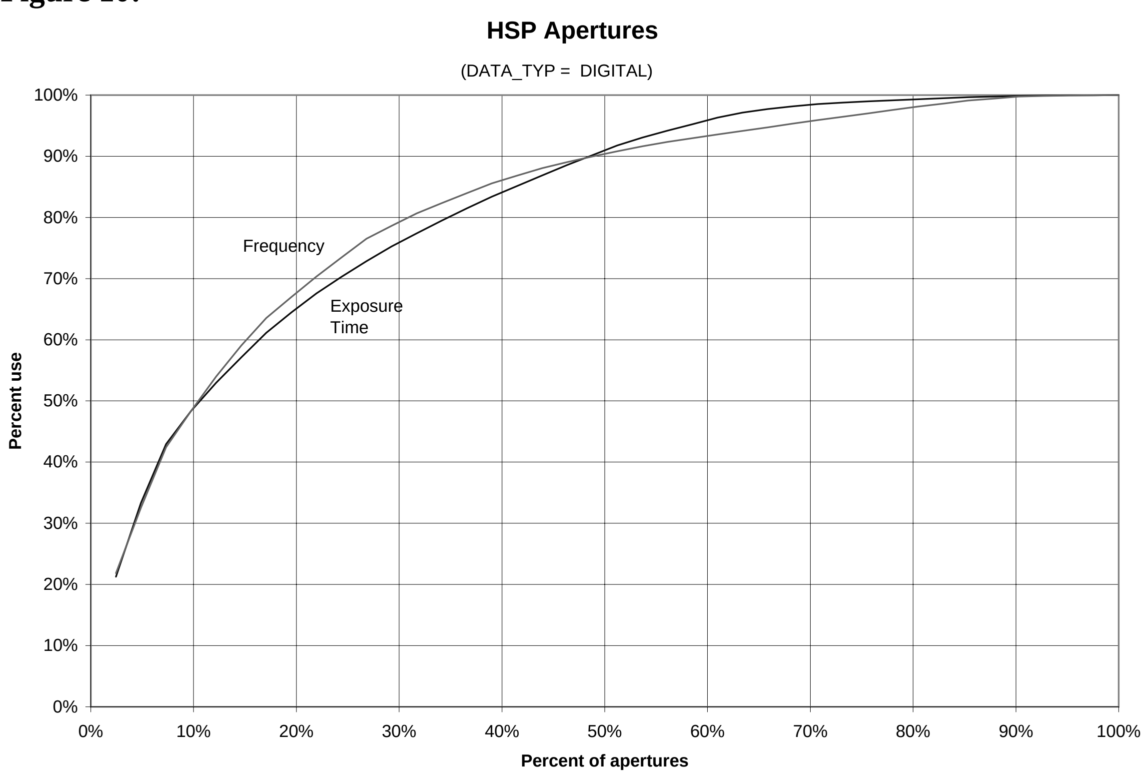
- Looking at individual elements within a “configuration”, gives further information. The data_typ = DIGITAL is used in 99% of the observations. This suggests that we could have eliminated the ANALOG data type, but the data_typ = ANALOG were used to calibrate the DIGITAL observations. In addition, this element value was used for bright observations and with the instrument in the data_type, it was used as a high current detector (safety).

- The vgaind parameter of the instrument had five values (2,3,6,7,NULL). The vgaind = NULL was used for 50% of the total observations, and vgaind = 7 was used 46% of the time. One might draw the conclusion that the other three values could have been eliminated to save cost. This situation is similar to the ANALOG data_typ case. These other values, while not used often, were needed to calibrate the popular choices.
- The detector use was fairly well spread over the five detectors, with the least used of the five being necessary for particular types of science.

2. Exposure Time Section

- Considering a mode consisting of data_typ,thresh,vgaind,detectob,voltage,apertobj, and comparing exposure time for each mode and the number of observations, we find that 90% (404476/450569 sec) of the time is used for 19% (948/5089) of the observations and 30% (301/1012) of the modes.
- Apertures vs. Exposure Time (DIGITAL). Only 49% (20/41) of the apertures/filters used 90% (386755/428872 sec) of the total time, which corresponds to 88% (4411/4903) of all of the observations. See figure 10.

Figure 10:



- Apertures vs. Exposure Time (ANALOG)
  The use of ANALOG data_typ is important for calibrations, but clearly not used very much. (19.1 seconds of time and 74 observations)

WFPC

The database queries used to generate this information looked into the **dadsops** database, at relations wfpc_ref_data and wfpc_data. Parameters limiting the queries were

```
where n.wcr_imagetyp="EXTERNAL"
```

and the data was taken between April 1990 and December 1993.

1. Combination Section

A mode (or configuration) existing of the combinations of filter1, filter2, camera, serials, and shutter is one possible definition. This gives us 7993 observations taken with 309 modes. The database shows that 90% (7200/7992) of the observations make use of only 33% (103/308) of the modes. See figure 11.
An example of a configuration would be

```
serials  =  OFF
camera   =  WF
filtnam1 =  F375M
filtnam2 =  NULL
shutter  = NULL
```

2. Individual Element Section

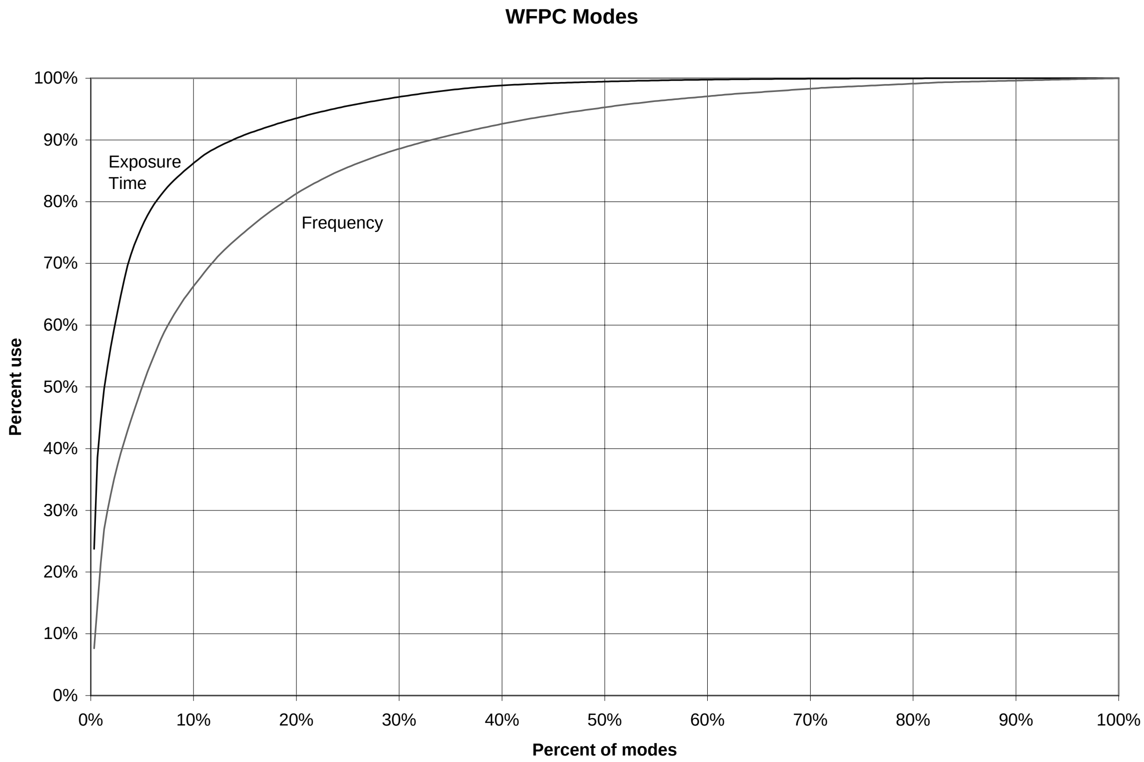
- The filters need be taken into account in combination (filter1/filter2). 90% (7225/7988) of the observations were made with only 26% (18/68) of the total filters.
- For the element of (SERIALS=ON), use was only 4% (295/7993), so we could downsize here as well. In this case, however, science capabilities would be lost. Saturated targets and bleeding control both need (SERIALS=ON).
- The use of the two different cameras, WF and PC was fairly well split, with the PC being used 65% of the time, and the WF at 35%.

** Special note ** In each of the case studies, there is a slightly different number in the total observations, (7988 vs. 7993). This discrepancy shows cases where both filters = NULL.

3. Exposure Time Section

- For the full mode, 90% (3632786/4030984 sec), 14% of modes (43/308). See figure 11.

Figure 11:



STIS

The database queries used to generate this information looked into the **dadsops** database, at relations stis_ref_data, stis_science, science.

Parameters limiting the queries were

```
where (s.sss_obsmode="ACCUM" or s.sss_obsmode="TIME-TAG"
or s.sss_obsmode="ACQ" or s.sss_obsmode="ACQ/PEAK")
and r.ssr_data_set_name=s.sss_data_set_name
and r.ssr_data_set_name=st.sci_data_set_name
and st.sci_data_set_name=s.sss_data_set_name
and st.sci_start_time > "Jan 15 1999"
and (st.sci_targname != "CCDFLAT" and st.sci_targname !=
"BIAS"
and st.sci_targname != "DARK" and st.sci_targname !=
"NONE")
and (r.ssr_proposid != 7910 and r.ssr_proposid != 7911 and
r.ssr_proposid != 7912 and r.ssr_proposid != 7908 and
r.ssr_proposid != 7675 and r.ssr_proposid != 7781 and
r.ssr_proposid != 7727 and r.ssr_proposid != 7782 and
r.ssr_proposid != 7700 and r.ssr_proposid != 7783 and
r.ssr_proposid != 8062 and r.ssr_proposid != 8064 and
r.ssr_proposid != 7639 and r.ssr_proposid != 8394 and
r.ssr_proposid != 7652 and r.ssr_proposid != 8406 and
r.ssr_proposid != 7653 and r.ssr_proposid != 8415 and
r.ssr_proposid != 8056 and r.ssr_proposid != 8416 and
r.ssr_proposid != 8084 and r.ssr_proposid != 8422 and
r.ssr_proposid != 8091 and r.ssr_proposid != 8470 and
r.ssr_proposid != 8393 and r.ssr_proposid != 8545 and
r.ssr_proposid != 8072 and r.ssr_proposid != 8549)
```

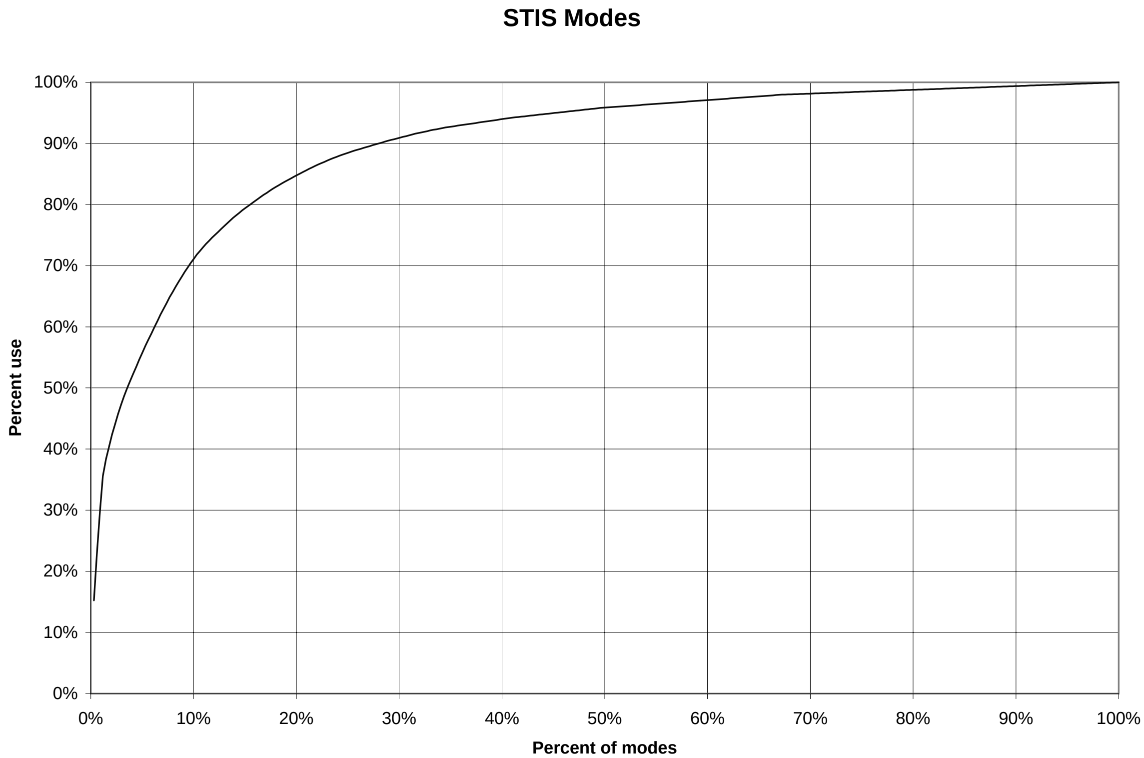
meaning: excluding all of these proposal ids, not counting target names = CCD-FLAT,BIAS,DARK,NONE; and where the obsmode equals to ACCUM, TIME-TAG, ACQ and ACQ/PEAK; and looking at only the post-NICMOS era (after Jan 15 1999), since the statistics would have been biased by NICMOS in the earlier time. See figure 13.

1. Combination Section

A mode (or configuration) consist of the combinations of ccdamp,ccdgain,cen-wave,obstype,aperture,detector,opt_elem,obsmode. Counting up all of the possible mode combinations versus all of the observations, we get 357 modes and 5747 observations. Looking at the frequency of use, it shows that only 28% of the modes were used to make 90% of the observations. See figure 12.

```
90% <=> (5176/5747); 28% <=> (101/357)
```

Figure 12:



An example of a configuration

```
ccdamp   - D
cenwave  - 3680
obstype  - SPECTROSCOPIC
aperture - 52X0.1
detector - CCD
opt_elem - G430M
obsmode  - ACCUM
ccdgain  - 1
```

2. Individual Elements Section

Looking at individual elements within a "configuration", gives further insight into possibilities for optimization of the instrument during initial construction.

- ccdamp - One value for the ccdamp came up in this query, ccdamp=D. The other three possible values did not figure into this search. However, these additional amplifiers provide redundancy, and a means of measuring the charge-transfer efficiency of the CCD. There is little extra cost in providing these extra amps during instrument construction. However, costs and effort in calibrating them for routine use were consciously avoided when STIS was put into service.
- ccdgain - The values for ccdgain (1,4) were used fairly evenly.

- cenwave - 90% (4969/5500) of the observations were made with only 17% (18/103) of the cenwave values. The cenwave values are soft choices. They would have made no difference in hardware cost.
- obstype - of the two obstype(s) IMAGING and SPECTROSCOPIC, the frequency of use is fairly even, with SPECTROSCOPIC being used 56% of the time.
- aperture- 90% (4963/5500) of the observations were made with only 32%(13/41) of the aperture values. Some hardware cost could have been saved with fewer apertures. Significant operational cost savings were achieved by not supporting all apertures.
- detector - Of the three detector values, the CCD was used for 70% of the observations, with FUV-MAMA at 19% and NUV-MAMA at 11%. While the MAMA use is significantly lower, they provide crucial scientific capability not measured in a representative way by this process of counting observations/exposures.
- opt_elem - 61% (11/18) of the opt_elem values were used for 90% (4948/5500) of the observations.
- obsmode - 77% of the observations used ACCUM mode. 11% - ACQ. 8% - ACQ/PEAK and 4% - TIME-TAG